Kentucky Method 64-424-03
Revised 1/10/03
Supersedes 64-001-99
Dated 12/20/99

METHOD FOR DESIGNING OPEN-GRADED FRICTION COURSE MIXTURES

1. SCOPE:

   1.1. This method describes the procedure for the design of Open-Graded Friction Course (OGFC) mixtures. This method is based on, and similar to, the Federal Highway Administration (FHWA) Technical Advisory T 5040.31.

   1.2. The proper completion of the instructions given in this procedure will result in the determination of the asphalt binder content (AC), mixing temperature, air void content, and moisture susceptibility of a given OGFC mixture.

   1.3. Refer to the attachments at the end of this method for: (1) a blank worksheet; (2) a completed example of the design of an OGFC mixture containing aggregate with "normal" absorptive properties; and (3) a completed example of the design of an OGFC mixture containing aggregate with "high" absorptive properties (see Subsection 4.1.3 of this method for a definition).

2. APPARATUS:

   2.1. Provide the equipment required to perform a sieve analysis in accordance with Kentucky Method (KM) 64-620, Wet Sieve Analysis of Fine and Coarse Aggregate.

   2.2. Provide the equipment required to perform aggregate specific gravity determinations in accordance with AASHTO T 84, Specific Gravity and Absorption of Fine Aggregate, and AASHTO T 85, Specific Gravity and Absorption of Coarse Aggregate.

   2.3. Provide the following equipment and materials that are necessary for determining the surface capacity of the predominant aggregate fraction (passing the 3/8-in. sieve and retained on the No. 4 sieve):

      2.3.1. Provide a metal funnel having a top diameter of 3.5 in., a height of 4.5 in., an orifice diameter of 0.5 in., and having a No. 10 sieve fastened to the bottom orifice.

      2.3.2. Provide one quart of a SAE No. 10 lubricating oil.

   2.4. Provide the following equipment that is necessary to determine the void capacity of the predominant-aggregate fraction:

2.4.1. Provide a compaction mold conforming to the following: a 6-in.-nominal diameter, solid-wall, metal cylinder with a detachable, metal base plate, as shown in Figure 1. Also provide a detachable, metal guide-reference bar.

2.4.2. Provide a portable, electromagnetic vibrating rammer, as shown in Figure 2, having a frequency of 3600 cycles per minute, suitable for use with 115-volt alternating current. Also provide a tamper foot and extension on the rammer, as shown in Figure 3.

2.4.3. Provide a wooden base consisting of a plywood disc, 15 in. in diameter, 2 in. thick, with a cushion (rubber hose) attached to the bottom. Construct the disc so it can be firmly attached to the base plate of the compaction mold.

2.4.4. Provide a stopwatch or other timing device graduated in divisions of 1.0 second, accurate to 1.0 second, and capable of timing the unit for up to 30 minutes. As an option, use an electric timing device or electrical circuits to start and stop the vibratory compactor.

2.4.5. Provide a dial indicator, graduated in 0.001-in. increments, with a travel range of 3.0 in.

3. PRELIMINARY AGGREGATE WORK:

3.1. Refer to KM 64-411, Preparing Ingredient Materials for, and Performing, a Laboratory Mix Design of an Asphalt Mixture, for the initial preparation and gradation of the aggregate(s).

3.2. Determine the apparent specific gravity for the predominant-aggregate fraction for each size and type of material to be utilized. Then, determine the bulk specific gravity for the coarse- (retained on the No. 8 sieve) and fine- (passing the No. 8 sieve) aggregate fractions for each size and type of material to be utilized. Perform all aggregate specific gravity determinations in accordance with AASHTO T 84 and T 85.

3.2.1. Given the proposed proportions of aggregates as determined and verified in Subsection 3.1 of this method, mathematically compute the apparent specific gravity of the predominant-aggregate fraction.

3.2.2. Given the proposed proportions of aggregates as determined and verified in Subsection 3.1 of this method, mathematically compute the bulk specific gravity for the coarse- and fine-aggregate fractions.

3.2.3. Given the proposed proportions of aggregates as determined and verified in

Subsection 3.1 of this method, calculate the combined bulk specific gravity of the aggregate, G_{sb}, as described in the MS-2 Manual, *Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types*, from the Asphalt Institute.

3.2.4. If the bulk specific gravities of the aggregate sources are significantly different, a gradation analysis based on aggregate weight will not reflect the actual particle-size distribution. In this case, re-examine the gradation of the aggregate blend on a volume basis for compliance with the applicable specifications.

4. DETERMINATION OF AC:

4.1. Determine the surface capacity of the predominant-aggregate fraction in accordance with the following procedure (complete this procedure three times to obtain an average):

4.1.1. "Quarter out" a minimum of 105 g of the predominant aggregate. Dry the sample to a constant weight in an oven at 230 ± 9 ^{o}F. Allow the sample to cool to room temperature.

4.1.2. Reduce the sample to 100.0 ± 1.0 g, and place the sample in a metal funnel (described in Subsection 2.3.1 of this method). Record the weight of the predominant-aggregate sample as "A."

4.1.3. Completely immerse the specimen in SAE No. 10 lubricating oil for five minutes at room temperature. If using highly absorptive aggregate, immerse the specimen for 30 minutes. For the purposes of this method, consider an OGFC mixture to contain highly absorptive aggregate if the combined water absorption of the individual aggregates comprising the mixture is greater than 3.5 %.

4.1.4. Drain the sample in the funnel for two minutes. Place the funnel containing the sample in an oven at 140 ± 5 ^{o}F for 15 minutes of additional drainage.

4.1.5. Pour the sample from the funnel into a tared pan; cool to room temperature, and weigh the sample to the nearest 0.1 g. Record this weight as "B."

4.1.6. Compute the percentage of retained oil, P_{ro}, using the following formula:

$$P_{ro} = 100\left[\frac{G_{sa}(B-A)}{2.65A}\right], where$$

P_{ro} = the percentage of retained oil;
G_{sa} = the apparent specific gravity of the predominant aggregate (as calculated in Subsection 3.2.1 of this method);
A = the oven-dry weight of the sample (g); and
B = the coated weight of the sample (g).

4.1.7. When performing this procedure with highly absorptive aggregate, perform the following additional steps to determine an "adjusted" value for P_{ro}.

4.1.7.1. After determining "B" as described in Subsection 4.1.5 of this method, pour the sample onto a clean, dry cloth and achieve a saturated, surface-dry condition.

4.1.7.2. Pour the sample from the cloth into a tared pan, and weigh the sample to the nearest 0.1 g. Record this weight as "C."

4.1.7.3. Compute the percentage of absorbed oil, P_{ao}, using the following formula:

$$P_{ao} = 100\left(\frac{C-A}{A}\right), where$$

P_{ao} = the percentage of absorbed oil;
C = the saturated, surface-dry weight of the sample (g); and
A = the oven-dry weight of the sample (g).

4.1.7.4. Determine the "adjusted" percentage of retained oil, P_{roa}, using the following formula:

$$P_{roa} = P_{ro} - P_{ao}, where$$

P_{roa} = the adjusted percentage of retained oil;
P_{ro} = the percentage of retained oil; and
P_{ao} = the percentage of absorbed oil.

4.1.8. Calculate the surface constant value, K_c, for the predominant aggregate using the following formula:

$$K_c = 0.1 + 0.4 P_{ro}, \textit{where}$$

K_c = the surface constant of the predominant aggregate; and
P_{ro} = the percentage of retained oil.

When performing this procedure with highly absorptive aggregate, use this formula for determining the "adjusted" surface constant, K_{ca}:

$$K_{ca} = 0.1 + 0.4 P_{roa}, \textit{where}$$

K_{ca} = the adjusted surface constant of the predominant aggregate; and
P_{roa} = the adjusted percentage of retained oil.

4.2. Calculate the required asphalt content, AC_{req}, based on the weight of total aggregate, using the following formula:

$$AC_{req} = \frac{2.65(2K_c + 4)}{G_{sa}}, \textit{where}$$

AC_{req} = the required AC (%);
K_c = the surface constant of the predominant aggregate (as calculated in Subsection 4.1.8 of this method); and
G_{sa} = the apparent specific gravity of the predominant aggregate (as calculated in Subsection 3.2.1 of this method).

4.3. When performing this procedure with highly absorptive aggregate, the formula for determining the effective asphalt content, Eff. AC, is:

$$Eff.AC = \frac{2.65(2K_{ca} + 4)}{G_{sa}}, \textit{where}$$

Eff. AC = the effective asphalt content (%);
K_{ca} = the adjusted surface constant of the predominant aggregate (as calculated in Subsection 4.1.8 of this method); and
G_{sa} = the apparent specific gravity of the predominant aggregate (as calculated in Subsection 3.2.1 of this method).

4.4. When performing this procedure with highly absorptive aggregate, complete Sections 5 and 6, and then continue with the determination of the AC as follows:

4.4.1. Prepare three trial mixtures using an AC equal to, or somewhat greater than (estimate the amount that will be absorbed), the effective asphalt content, Eff. AC, as determined in Subsection 4.3 of this method, and using the aggregate gradation, as determined in Subsection 6.2 of this method.

4.4.2. In accordance with AASHTO T 209, Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures, determine the theoretical maximum specific gravity, G_{mm}, of each trial mixture. Include the Supplemental Procedure for Mixtures Containing Porous Aggregate in AASHTO T 209. Average the results of the three trial mixtures.

4.4.3. In accordance with the MS-2 Manual, calculate the effective specific gravity of the aggregate, G_{se}, using the AC from Subsection 4.03 of this method.

4.4.4. In accordance with the MS-2 Manual, calculate the percent of absorbed asphalt, by weight of total aggregate, Abs. AC, using G_{sb} as determined in Subsection 3.2.3 of this method.

4.4.5. Determine the AC_{req} of the absorptive mixture using the following formula:

$$AC_{req} = Eff.AC + Abs.AC, where$$

AC_{req} = the required AC (%);
Eff. AC = the effective AC (%), as calculated in Subsection 4.3 of this method; and
Abs. AC = the absorbed AC, by weight of total aggregate (%), as calculated in Subsection 4.4.4 of this method.

5. VIBRATED UNIT WEIGHT AND VOID CAPACITY OF COARSE AGGREGATE:

5.1. Determine the vibrated unit weight of the coarse-aggregate fraction of the proposed JMF.

5.1.1. "Weigh-up" a sample of the coarse-aggregate fraction (approximately 5 lb_m) from the proposed JMF. If the bulk specific gravity of the coarse aggregate is less than 2.000, reduce the size of the sample to approximately 3.5 lb_m. Weigh the sample to the nearest 0.1 lb_m. Record this weight as "W."

5.1.2. Pour the sample into the compaction mold, and place the tamper foot on the sample. Place the guide-reference bar over the shaft of the tamper foot, and secure the bar to the mold with the thumb screws.

5.1.3. Place the vibratory rammer on the shaft of the tamper foot, and vibrate for 15 seconds. During the vibration period, exert just enough pressure on the hammer to maintain contact between the sample and the tamper foot. Practice operating the vibratory rammer and maintaining pressure on the hammer prior to actually performing this process.

5.1.4. In order to obtain the thickness of the compacted material, t, the height of the mold wall (from top to bottom) must be determined to the nearest 0.01 in. After the 15-second vibration period described in Subsection 5.1.3 of this method, remove the vibratory rammer from the shaft of the tamper foot, and brush any fines from the top of the tamper foot. Then, measure the distance from the top of the mold to the layer of compacted material to the nearest 0.01 in. in at least three different locations around the circumference of the mold, and average these values. The difference between this averaged value and the height of the empty mold is the thickness of the compacted material, t.

5.1.5. Calculate the vibrated unit weight of the coarse-aggregate fraction, U_v, as follows:

$$U_v = \frac{6912W}{\pi d^2 t}, where$$

U_v = the vibrated unit weight of the coarse-aggregate fraction (lb_m/ft^3);
W = the weight of the coarse-aggregate fraction (lb_m);
D = the diameter of the compaction mold (in.) = 6 in.; and
T = the thickness of the vibrated material (in.).

If W = 5 lb_m, use the following simplified formula:

$$U_v = \frac{305.73}{t}$$

5.2. Calculate the void capacity of the coarse-aggregate fraction, V_c, as a percent of the total volume, using the following formula:

$$V_c = 100\left(1 - \frac{U_v}{U_c}\right), where$$

V_c = the void capacity of the coarse-aggregate fraction (%);
U_v = the vibrated unit weight of the coarse-aggregate fraction (lb_m/ft^3) as calculated in Subsection 5.1.5 of this method; and
U_c = the bulk-dry solid unit weight of the coarse-aggregate fraction (lb_m/ft^3) = the bulk specific gravity of the coarse-aggregate fraction multiplied by 62.4.

5.3. Complete Subsections 5.1 and 5.2 of this method three times to obtain average values for U_v and V_c, respectively.

6. OPTIMUM CONTENT OF FINE AGGREGATE:

6.1. Calculate the optimum-fine-aggregate content, F, with the following formula:

$$F = \frac{V_c - V - \frac{AC_{req} U_v}{U_a}}{\frac{V_c - V}{100} + \frac{U_v}{U_f}}, where$$

F = the optimum-fine-aggregate content by weight of the total aggregate (%);
V_c = the void capacity of the coarse-aggregate fraction (%) as calculated in Subsection 5.3 of this method;
V = the design air void content (%) = 15.0 %;
AC_{req} = the required AC (%), when using this procedure for highly absorptive aggregate, use Eff. AC from Subsection 4.3 of this method, not AC_{req};
U_v = the vibrated unit weight of the coarse-aggregate fraction (lb_m/ft^3) as calculated in Subsection 5.3 of this method;
U_a = the unit weight of the asphalt binder = 64.272 lb_m/ft^3; and
U_f = the bulk-dry solid unit weight of the fine-aggregate fraction (lb_m/ft^3) = the bulk specific gravity of the fine-aggregate fraction multiplied by 62.4.

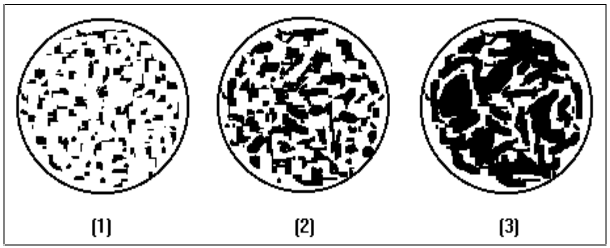
6.2. Compare the optimum-fine-aggregate content, F, determined in Subsection 6.1 of this method, to the amount passing the No. 8 sieve of the proposed JMF. If these values differ by more than one percent, revise the JMF using the value determined for the optimum fine- aggregate content. Recalculate the proportions of coarse and fine aggregates to meet the revised JMF. If the proposed and revised JMF gradations are significantly different, it may be necessary to perform portions of this procedure again.

7. DETERMINATION OF MIXING TEMPERATURE:

7.1. Prepare a sample of aggregate (approximately 1000 g) in the proportions determined in Subsection 6.2 of this method. As a “starting point,” mix this sample with the asphalt binder at the AC determined in Subsection 4.2 of this method (or Subsection 4.4.5 of this method when using highly absorptive aggregate) at a mixing temperature of 225 ^oF for performance-graded (PG) 64-22 asphalt binder, 240 ^oF for PG 70-22, and 265 ^oF for PG 76-22. When the aggregate is completely coated, transfer the mixture to a Pyrex glass plate (8 - 9 in. in diameter), and spread the mixture with a minimum of manipulation.

7.02 Place the plate, with the sample, in the oven at the mixing temperature. Observe the bottom of the plate after 60 minutes. A slight puddle of asphalt binder at the points of contact between the aggregate and the glass plate, as shown in Case (2) of Figure 4, is suitable and desirable after the 60-minute period. Otherwise, repeat the test at a higher or lower mixing temperature to achieve the desired contact area. If asphalt drainage occurs at a mixing temperature that is too low to provide for adequate drying of the aggregate (typically not lower than 225 ^{o}F), use an asphalt binder of a higher viscosity.

Figure 4. "Drain-Down" Characteristics.



(1) Little "drain-down;" increase the mixing temperature.

(2) Desired "drain-down;" optimum mixing temperature.

(3) Excessive "drain-down;" decrease the mixing temperature.

7.3. Make an intermediate observation of the plate after 15 minutes. If excessive "drain-down" occurs at the contact points after 15 minutes, discard the sample, and repeat the test at a lower temperature.

8. DETERMINATION OF RESISTANCE TO EFFECTS OF WATER:

8.1. Complete KM 64-423, Effect of Water on Cohesion of Compacted Asphalt Mixtures, on the designed mixture.

8.2. As directed by the Department, use liquid anti-stripping additives that provide adequate retained strength.

APPROVED ____

Director
DIVISION OF MATERIALS

DATE ______1/10/03______________________________

Kentucky Method 64-424-03
Revised 1/10/03
Supersedes 64-001-99
Dated 12/20/99

Attachments K4240103.doc

Kentucky Transportation Cabinet, Department of Highways, Division of Materials
Asphalt Mixtures Testing Section
1227 Wilkinson Boulevard, Frankfort, KY 40601-1226

OPEN-GRADED FRICTION COURSE (OGFC) MIX-DESIGN WORKSHEET

Mix ID # & County: ____________________ Tested By: ____________________

Date Received: ____________________ Date Completed: ____________________

Test Method(s) Used: KM 64-424 & KM 64-423 Lab: 000

1. MATERIAL PROPERTIES

A. Proposed Job-Mix Formula (JMF)

Sieve Size	Individual Gradations				Proposed JMF	Specification Limits
	Agg. # 1	Agg. # 2	Agg. # 3	Agg. # 4		
1/2 in.						100
3/8 in.						90 - 100
No. 4						25 - 50
No. 8						5 - 15
No. 200						2.0 - 5.0

B. Proposed Aggregate Proportions and Specific Gravities

Agg. #	Agg. Type & Size	Percent	G_{sa} (Predom. Agg.)	G_{sb} (Coarse Agg.)	G_{sb} (Fine Agg.)
1					
2					
3					
4					
Combined Totals		100			
Bulk-Dry Solid Unit Weight (lb_m/ft^3)				U_c =	U_f =
Combined G_{sb} of Total Aggregate					

Predominant Aggregate = Passing 3/8-in. sieve and retained on No. 4 sieve.
Coarse Aggregate = Retained on No. 8 sieve.
Fine Aggregate = Passing No. 8 sieve.

C. Asphalt Properties

Unit Weight (64.272 lb_m/ft^3) ________________

2. ASPHALT CONTENT

A. Aggregate With "Normal" Absorptive Properties

Sample Property	Test # 1	Test # 2	Test # 3	Average
Sample Weight, Dry, A (g)				
Sample Weight, After Submersion, B (g)				
Retained Oil, P_{ro} (%)				
Surface Constant, K_c				
Required Asphalt Content, AC_{req} (%), by Weight of Total Aggregate				

B. Aggregate With "High" Absorptive Properties

Sample Property	Test # 1	Test # 2	Test # 3	Average
Sample Weight, Dry, A (g)				
Sample Weight, After Submersion, B (g)				
Retained Oil, P_{ro} (%)				
Sample Weight, SSD, C (g)				
Absorbed Oil, P_{ao} (%)				
Retained Oil, Adjusted, P_{roa} (%)				
Adjusted Surface Constant, K_{ca}				
Effective Asphalt Content, Eff. AC (%)				

Note: Complete Sections 5 and 6 in KM 64-424, then continue AC determination.

Sample Property	Test # 1	Test # 2	Test # 3	Average
G_{mm} of Trial Mixtures				
Effective Specific Gravity of Agg., G_{se}				
Absorbed Asphalt (Agg.), Abs. AC (%)				
Required Asphalt Content, AC_{req} (%), by Weight of Total Aggregate				

3. VIBRATED UNIT WEIGHT AND VOID CAPACITY OF COARSE AGGREGATE

Sample Property	Test # 1	Test # 2	Test # 3	Average
Sample Weight, W (lb_m)				
Thickness of Compacted Material, t (in.)				
Vibrated Unit Weight, U_v (lb_m/ft^3)				
Void Capacity, V_c (%)				

4. OPTIMUM-FINE-AGGREGATE CONTENT

Optimum-Fine-Aggregate Content, F (%)________

Note: When determining F for aggregate with "high" absorptive properties, use Eff. AC in formula, not AC_{req}. Compare F to proposed JMF on No. 8 sieve. If different by more than 1 %, revise JMF on No. 8 sieve to F, and recalculate other sieves accordingly.

5. OPTIMUM MIXING TEMPERATURE

Trial Temperature (°F)	Observed Drainage

Performance-Graded (PG) Binder ________

Target Mixing Temperature (°F) ________

6. RESISTANCE TO EFFECTS OF WATER (KM 64-423)

Average Load of Control Specimens, S_1 (lb_f) ________

Average Load of Test Specimens, S_2 (lb_f) ________

Resistance to Effects of Water, R_r (%) ________ (70 %, minimum)

7. MIX-DESIGN SUMMARY

Sieve Size	Specification Limits	Revised JMF
1/2 in.	100	
3/8 in.	90 - 100	
No. 4	25 - 50	
No. 8	5 - 15	
No. 200	2.0 - 5.0	

PG Binder ________

Percent and Type of Additive ________________________________

Required AC ________ %, by weight of aggregate, AC_{req}

________ %, by weight of mix

Mixing Temperature Range ________ to ________ ^{o}F

8. DEVIATIONS FROM TEST METHOD

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9. MIX-DESIGN RECOMMENDATIONS

Accepted ________ Rejected ________

Kentucky Transportation Cabinet, Department of Highways, Division of Materials

Asphalt Mixtures Testing Section

1227 Wilkinson Boulevard, Frankfort, KY 40601-1226

OPEN-GRADED FRICTION COURSE (OGFC) MIX-DESIGN WORKSHEET

Mix ID # & County: # 375, Remington Co.

Tested By: B. Dance

Date Received: February 12, 1999

Date Completed: February 28, 1999

Test Method(s) Used: KM 64-424 & KM 64-423

Lab: 000

1. MATERIAL PROPERTIES

A. Proposed Job-Mix Formula (JMF)

Sieve Size	Individual Gradations				Proposed JMF	Specification Limits
	Agg. # 1	Agg. # 2	Agg. # 3	Agg. # 4		
1/2 in.	100	100			100	100
3/8 in.	90	100			92	90 - 100
No. 4	20	82			32	25 - 50
No. 8	2	55			13	5 - 15
No. 200	1.5	13.5			4.0	2.0 - 5.0

B. Proposed Aggregate Proportions and Specific Gravities

Agg. #	Agg. Type & Size	Percent	G_{sa} (Predom. Agg.)	G_{sb} (Coarse Agg.)	G_{sb} (Fine Agg.)
1	Granite # 8's	80	2.710	2.659	2.632
2	Limestone Sand	20	2.698	2.649	2.644
3					
4					
Combined Totals		100	2.708	2.657	2.634
Bulk-Dry Solid Unit Weight (lb_m/ft^3)				U_c = 165.8	U_f = 164.4
Combined G_{sb} of Total Aggregate				2.656	

Predominant Aggregate = Passing 3/8-in. sieve and retained on No. 4 sieve.

Coarse Aggregate = Retained on No. 8 sieve.

Fine Aggregate = Passing No. 8 sieve.

C. Asphalt Properties

Unit Weight (64.272 lb_m/ft^3) 64.272

2. ASPHALT CONTENT

A. Aggregate With "Normal" Absorptive Properties

Sample Property	Test # 1	Test # 2	Test # 3	Average
Sample Weight, Dry, A (g)	100.0	100.1	99.9	
Sample Weight, After Submersion, B (g)	102.1	102.3	102.2	
Retained Oil, P_{ro} (%)	2.15	2.25	2.35	
Surface Constant, K_c	0.96	1.00	1.04	
Required Asphalt Content, AC_{req} (%), by Weight of Total Aggregate	5.8	5.9	6.0	5.9

B. Aggregate With "High" Absorptive Properties

Sample Property	Test # 1	Test # 2	Test # 3	Average
Sample Weight, Dry, A (g)				
Sample Weight, After Submersion, B (g)				
Retained Oil, P_{ro} (%)				
Sample Weight, SSD, C (g)				
Absorbed Oil, P_{ao} (%)				
Retained Oil, Adjusted, P_{roa} (%)				
Adjusted Surface Constant, K_{ca}				
Effective Asphalt Content, Eff. AC (%)				

Note: Complete Sections 5 and 6 in KM 64-424, then continue AC determination.

Sample Property	Test # 1	Test # 2	Test # 3	Average
G_{mm} of Trial Mixtures				
Effective Specific Gravity of Agg., G_{se}				
Absorbed Asphalt (Agg.), Abs. AC (%)				
Required Asphalt Content, AC_{req} (%), by Weight of Total Aggregate				

3. VIBRATED UNIT WEIGHT AND VOID CAPACITY OF COARSE AGGREGATE

Sample Property	Test # 1	Test # 2	Test # 3	Average
Sample Weight, W (lb_m)	5	5	5	
Thickness of Compacted Material, t (in.)	2.88	2.83	2.86	
Vibrated Unit Weight, U_v (lb_m/ft^3)	106.2	108.0	106.9	107.0
Void Capacity, V_c (%)	36.1	35.0	35.5	35.5

4. OPTIMUM-FINE-AGGREGATE CONTENT

Optimum-Fine-Aggregate Content, F (%) 13

Note: When determining F for aggregate with "high" absorptive properties, use Eff. AC in formula, not AC_{req}. Compare F to proposed JMF on No. 8 sieve. If different by more than 1 %, revise JMF on No. 8 sieve to F, and recalculate other sieves accordingly.

5. OPTIMUM MIXING TEMPERATURE

Trial Temperature (^oF)	Observed Drainage
210	None
250	Little
285	Excessive
260	Desired

Performance-Graded (PG) Binder PG 64-22

Target Mixing Temperature (^oF) 260

6. RESISTANCE TO EFFECTS OF WATER (KM 64-423)

Average Load of Control Specimens, S_1 (lb_f) 678

Average Load of Test Specimens, S_2 (lb_f) 592

Resistance to Effects of Water, R_r (%) 87 (70 %, minimum)

7. MIX-DESIGN SUMMARY

Sieve Size	Specification Limits	Revised JMF
1/2 in.	100	100
3/8 in.	90 - 100	92
No. 4	25 - 50	32
No. 8	5 - 15	13
No. 200	2.0 - 5.0	4.0

PG Binder PG 64-22

Percent and Type of Additive 0.5 % Pave Bond Lite

Required Asphalt Content 5.9 %, by weight of aggregate, AC_{req}

5.6 %, by weight of mix

Mixing Temperature Range 250 to 270 ^{o}F

8. DEVIATIONS FROM TEST METHOD

Vibrating rammer remained on Sample # 2 for 17 seconds.

9. MIX-DESIGN RECOMMENDATIONS

Accepted X Rejected ______

Kentucky Transportation Cabinet, Department of Highways, Division of Materials
Asphalt Mixtures Testing Section
1227 Wilkinson Boulevard, Frankfort, KY 40601-1226

OPEN-GRADED FRICTION COURSE (OGFC) MIX-DESIGN WORKSHEET

Mix ID # & County: # 375, Remington Co.
Tested By: B. Dance
Date Received: February 12, 1999
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Test Method(s) Used: KM 64-424 & KM 64-423
Lab: 000

1. MATERIAL PROPERTIES

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Sieve Size	Individual Gradations				Proposed JMF	Specification Limits
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1/2 in.	100	100			100	100
3/8 in.	90	100			92	90 - 100
No. 4	20	82			32	25 - 50
No. 8	2	55			13	5 - 15
No. 200	1.5	13.5			4.0	2.0 - 5.0

B. Proposed Aggregate Proportions and Specific Gravities

Agg. #	Agg. Type & Size	Percent	G_{sa} (Predom. Agg.)	G_{sb} (Coarse Agg.)	G_{sb} (Fine Agg.)
1	Granite # 8's	80	2.710	2.659	2.632
2	Limestone Sand	20	2.698	2.649	2.644
3					
4					
Combined Totals		100	2.708	2.657	2.634
Bulk-Dry Solid Unit Weight (lb_m/ft^3)				U_c = 165.8	U_f = 164.4
Combined G_{sb} of Total Aggregate				2.656	

Predominant Aggregate = Passing 3/8-in. sieve and retained on No. 4 sieve.
Coarse Aggregate = Retained on No. 8 sieve.
Fine Aggregate = Passing No. 8 sieve.

C. Asphalt Properties

Unit Weight (64.272 lb_m/ft^3) 64.272

2. ASPHALT CONTENT

A. Aggregate With "Normal" Absorptive Properties

Sample Property	Test # 1	Test # 2	Test # 3	Average
Sample Weight, Dry, A (g)				
Sample Weight, After Submersion, B (g)				
Retained Oil, P_{ro} (%)				
Surface Constant, K_c				
Required Asphalt Content, AC_{req} (%), by Weight of Total Aggregate				

B. Aggregate With "High" Absorptive Properties

Sample Property	Test # 1	Test # 2	Test # 3	Average
Sample Weight, Dry, A (g)	100.0	100.1	99.9	
Sample Weight, After Submersion, B (g)	102.1	102.3	102.2	
Retained Oil, P_{ro} (%)	2.15	2.25	2.35	
Sample Weight, SSD, C (g)	101.1	101.0	101.0	
Absorbed Oil, P_{ao} (%)	1.10	0.90	1.10	
Retained Oil, Adjusted, P_{roa} (%)	1.05	1.35	1.25	
Adjusted Surface Constant, K_{ca}	0.52	0.64	0.60	
Effective Asphalt Content, Eff. AC (%)	4.9	5.2	5.1	5.1

Note: Complete Sections 5 and 6 in KM 64-424, then continue AC determination.

Sample Property	Test # 1	Test # 2	Test # 3	Average
G_{mm} of Trial Mixtures (@ 6.2 % AC)	2.500	2.503	2.502	2.502
Effective Specific Gravity of Agg., G_{se}				2.763
Absorbed Asphalt (Agg.), Abs. AC (%)				1.50
Required Asphalt Content, AC_{req} (%), by Weight of Total Aggregate				6.6

3. VIBRATED UNIT WEIGHT AND VOID CAPACITY OF COARSE AGGREGATE

Sample Property	Test # 1	Test # 2	Test # 3	Average
Sample Weight, W (lb_m)	5	5	5	
Thickness of Compacted Material, t (in.)	2.88	2.83	2.86	
Vibrated Unit Weight, U_v (lb_m/ft^3)	106.2	108.0	106.9	107.0
Void Capacity, V_c (%)	36.1	35.0	35.5	35.5

4. OPTIMUM-FINE-AGGREGATE CONTENT

Optimum-Fine-Aggregate Content, F (%) 14

Note: When determining F for aggregate with "high" absorptive properties, use Eff. AC in formula, not AC_{req}. Compare F to proposed JMF on No. 8 sieve. If different by more than 1 %, revise JMF on No. 8 sieve to F, and recalculate other sieves accordingly.

5. OPTIMUM MIXING TEMPERATURE

Trial Temperature (^oF)	Observed Drainage
195	None
230	Little
265	Excessive
240	Desired

Performance-Graded (PG) Binder PG 64-22

Target Mixing Temperature (^oF) 240

6. RESISTANCE TO EFFECTS OF WATER (KM 64-423)

Average Load of Control Specimens, S_1 (lb_f) 679

Average Load of Test Specimens, S_2 (lb_f) 569

Resistance to Effects of Water, R_r (%) 84 (70 %, minimum)

7. MIX-DESIGN SUMMARY

Sieve Size	Specification Limits	Revised JMF
1/2 in.	100	100
3/8 in.	90 - 100	92
No. 4	25 - 50	32
No. 8	5 - 15	13
No. 200	2.0 - 5.0	4.0

PG Binder PG 64-22

Percent and Type of Additive 0.5 % Pave Bond Lite

Required Asphalt Content 6.6 %, by weight of aggregate, AC_{req}

6.1 %, by weight of mix

Mixing Temperature Range 230 to 250 ^{o}F

8. DEVIATIONS FROM TEST METHOD

Vibrating rammer remained on Sample # 2 for 17 seconds.

9. MIX-DESIGN RECOMMENDATIONS

Accepted X Rejected ________